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[Title of the Invention] OPTICAL WAVEGUIDE APPARATUS

[Abstract]
[Object]

In an optical waveguide apparatus, to increase flexibility in device arrangement using a two-dimensional waveguide and a special optical input/output terminal device.

[Solving Means]

End portions of optical input/output terminal devices 312 and 322 are brought close to, brought in contact with, or inserted in a two-dimensional optical waveguide 1 two-dimensionally expanding to guide light from optical output sections of optical devices optically coupled to the other end portions of the optical input/output terminal devices 312 and 322 or light to be inputted into optical input sections of the optical devices through the two-dimensional waveguide 1.

[Claims]

[Claim 1]

An optical waveguide apparatus characterized in that an end of an optical input/output terminal device is brought close to, brought in contact with, or inserted into a two-dimensional optical waveguide two-dimensionally expanding and that light from an optical output section of an optical device optically coupled to the other end of the optical input/output terminal device or light to be inputted to an optical input section of the optical device is guided by the two-dimensional optical waveguide.

[Claim 2]

The optical waveguide apparatus according to claim 1, wherein an device including an optical device outputting light, an electronic circuit, and the optical input/output terminal device and an device including an optical device receiving light, an electronic circuit, and the optical input/output terminal device are provided on the two-dimensional optical waveguide, and transmission and reception of optical signals are performed between the optical devices through the two-dimensional optical waveguide.

[Claim 3]

The optical waveguide apparatus according to claim 2, wherein the plurality of devices are constituted as optoelectronic devices, which individually include electrical terminals connected to each other through an electrical wire and transmit and receive electrical signals to and from each other.

[Claim 4]

The optical waveguide apparatus according to any one of claims 2 and 3, wherein the plurality of devices further include another optical device outputting light and another optical device receiving light, respectively, and the another optical devices are connected to each other by light propagating in air.

[Claim 5]

The optical waveguide apparatus according to any one of claims 2 to 4, wherein two or more pairs of devices each including an optical device transmitting and receiving light to the other optical device of the same pair, an electronic circuit, and the optical input/output terminal device are provided on the two-dimensional optical waveguide, and the different pairs perform transmission and reception of optical signals having different wavelengths through the two-dimensional optical waveguide.

[Claim 6]

The optical waveguide apparatus according to any one of claims 2 to 5, wherein each of the plurality of devices includes each constituent provided on an electronic circuit/optical device substrate and is placed on the two-dimensional optical waveguide.

[Claim 7]

The optical waveguide apparatus according to any one of claims 2 to 6, wherein the plurality of devices are placed on a substrate provided on the two-dimensional optical waveguide.

[Claim 8]

The optical waveguide apparatus according to claim 7, wherein the substrate is stacked on the two-dimensional optical waveguide.

[Claim 9]

The optical waveguide apparatus according to claim 7, the substrate and the two-dimensional optical waveguide are layered on each other.

[Claim 10]

The optical waveguide apparatus according to any one of claims 2 to 6, wherein the plurality of devices are placed on the two-dimensional optical waveguide directly or with the electronic circuit/optical device substrate interposed therebetween.

[Claim 11]

The optical waveguide apparatus according to claim 10, wherein an electrical wire is formed on a surface of the two-dimensional optical waveguide.

[Claim 12]

The optical waveguide apparatus according to any one of claims 1 to 11, wherein an optical input/output terminal device having a needle-shaped end stuck in the two-dimensional optical waveguide is provided.

[Claim 13]

The optical waveguide apparatus according to claim 12, wherein the optical input/output terminal device is composed of an optical fiber with an end sharply machined.

[Claim 14]

The optical waveguide apparatus according to any one of claims 1 to 11, wherein an optical input/output terminal device formed of an optical waveguide is provided and an end face of the optical waveguide is pressed against the two-dimensional optical waveguide to couple an optical signal traveling in the optical waveguide and light propagating within the two-dimensional optical waveguide by scattering at a portion of the two-dimensional optical waveguide abutting on a pressure contact portion of the optical waveguide.

[Claim 15]

The optical waveguide apparatus according to claim 14, wherein a force pressing the end face of the optical waveguide against the two-dimensional optical waveguide is adjusted to properly set the degree of scattering at the portion of the two-dimensional optical wavelength abutting on the pressure contact portion of the optical waveguide.

[Claim 16]

The optical waveguide apparatus according to any one of claims 1 to 11, wherein a corrugated or rough surface is formed in the surface of the two-dimensional optical wavelength and the end face of the optical input/output terminal device is brought close to or in contact with the corrugated or rough surface to couple an optical signal traveling in the optical input/output terminal device and light propagating within the two-dimensional optical waveguide by scattering at the corrugated or rough surface.

[Claim 17]

The optical waveguide apparatus according to any one of claims 1 to 11, wherein a scatterer is incorporated in the two-dimensional optical waveguide and the end face of the optical input/output terminal device is brought close to or in contact with a portion where the scatterer is incorporated to couple an optical signal traveling in the optical input/output terminal device and light propagating within the two-dimensional optical waveguide.

[Claim 18]

The optical waveguide apparatus according to any one of claims 1 to 11, wherein an optical input/output terminal device composed of a prism is provided and an end face of the prism is in contact with the surface of the two-dimensional optical waveguide.

[Claim 19]

The optical waveguide apparatus according to any one of claims 1 to 18, wherein an optical input/output terminal device formed to be capable of emitting light in all directions of 360 degrees within the two-dimensional optical waveguide is provided.

[Claim 20]

The optical waveguide apparatus according to any one of claims 1 to 19, wherein an optical input/output terminal device formed to be capable of receiving light propagating from an arbitrary direction within the two-dimensional optical waveguide is provided.

[Claim 21]

The optical waveguide apparatus according to any one of claims 1 to 20, wherein an optical input/output terminal device formed to emit light in a certain angular range within the two-dimensional optical waveguide is provided.

[Claim 22]

The optical waveguide apparatus according to any one of claims 1 to 21, wherein an optical input/output terminal device formed to receive light propagating in a certain angular range within the two-dimensional optical waveguide is included.

[Claim 23]

The optical waveguide apparatus according to any one of claims 1 to 22, wherein the two-dimensional optical waveguide is composed of a core sandwiched by clads.

[Claim 24]

An optical waveguide method, characterized in that an end of an optical input/output terminal device is either brought close to, brought in contact with, or inserted into a two-dimensional optical waveguide two-dimensionally expanding and that light from an optical output section of an optical device optically coupled to the other end of the optical input/output terminal device or light to be inputted to an optical input section of the optical device is guided by the two-dimensional optical waveguide.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an optical waveguide apparatus which guides light treated by an optical device using a two-dimensional optical waveguide expanding two-dimensionally, and typically, relates to an optical waveguide apparatus constituted as an optoelectronic apparatus which connects devices each including an optical terminal and an electrical terminal to each other using a two-dimensional optical waveguide and electrical wiring.

[0002]

As conventional means used for connecting optical devices, there is an optical waveguide plate described in the Japanese Patent Laid-open Publication No. 7-98463,

for example. FIG. 13 shows a side view of the structure thereof. In the drawing, reference numeral 807 denotes an optical waveguide plate (three-layer structure including two transparent layers 808 and 809 and a reflective layer 810); 802, a light emitting device; 803, a light receiving device; 801, a signal processing circuit; 811 and 812, lenses formed on the optical waveguide plate 807; and 805, a light beam.

[0003]

The operation of the above conventional example is briefly described. Light outputted from the light emitting device 802 is collected and changes direction by the lens 811. The light then reaches the reflective layer 810 of the optical waveguide plate 807 to be reflected. The light reflected by the reflective layer 810 is collected by the lens 812 into the light receiving device 803. As described above, data can be transmitted from the light emitting device 802 to the light receiving device 803.

[0004]

[Problems to be Solved by the Invention]

However, in the above conventional example, the route connecting two points is formed using the lenses 811 and 812 formed on the surface of the optical waveguide plate and the reflective layer 810, and there have been the following problems:

1) Space is necessary between the optical devices (the light emitting and receiving devices) and the optical waveguide plate.

2) The lenses need to be previously formed in the optical waveguide plate, and there is no flexibility in the arrangement.

3) The route between the devices is previously set.

[0005]

In the light of the aforementioned problems, an object of the present invention is to provide an optical waveguide apparatus, such as an optoelectronic apparatus, with flexibility in device arrangement improved by using a two-dimensional optical waveguide and a special light input/output terminal device and provide an optical waveguide method.

[0006]

[Means for Solving the Problems and Operation]

An optical waveguide apparatus of the present invention to achieve the aforementioned object is characterized in that an end of an optical input/output terminal device is brought close to, brought in contact with, or inserted into a two-dimensional optical waveguide two-dimensionally expanding and that light from an optical output section of an optical device optically coupled to the other end of the optical input/output terminal device or light to be inputted to an optical input section of the optical device is guided by the two-dimensional optical waveguide. This basic configuration can provide extremely great flexibility in arrangement of the optical output/input terminal device and optical device, thus increasing, for example, the flexibility in arrangement of devices arranged on a substrate, such as integrated circuits.

[0007]

Based on the above basic configuration, the following aspects are possible. On the two-dimensional optical waveguide, an device including an optical device outputting light, an electronic circuit such as driving the optical device, and the optical input/output terminal device optically coupled to the optical device and an device including an optical

device receiving light, an electronic circuit including such as a reception circuit for the optical device, and the optical input/output terminal device optically coupled to the optical device are provided. Between the optical devices, transmission and reception of optical signals are performed through the two-dimensional optical waveguide.

[0008]

The plurality of devices can be constituted as optoelectronic devices, which individually include electrical terminals connected to each other through an electrical wire and transmit and receive an electrical signal to and from each other. With this configuration, in signal transfer between the devices, optical signals and electrical signals are used according to the purposes. Compared to data transfer between the devices implemented with only electrical signals or only optical signals, the electrical and optical signals can be used for proper data transfer, thus increasing the flexibility in circuit configuration. Using the transfer media for electrical signals and for optical signals as described above can reduce a difference in data arrival time between the devices and thus increase the rate at which signals are transferred. It is therefore possible to eliminate the restriction from the configuration using only electrical signals, where the device arrangement is restricted, and to further increase the flexibility in device arrangement.

[0009]

The plurality of devices further includes another optical device outputting light and another optical device receiving light, respectively, and the another optical devices can be also connected to each other with light propagating in air. The configuration in which a transmission path in air is formed between the devices can provide three options for connection between adjacent devices: electrical interconnection, the two-dimensional waveguide, and over-air interconnection, thus further increasing the flexibility in arrangement.

[0010]

Two or more pairs of devices each including an optical device, an electronic circuit, and the optical input/output terminal device and transmitting and receiving light to and from each other are provided on the two-dimensional optical waveguide. The different pairs can be configured to perform transmission and reception of optical signals having different wavelengths through the two-dimensional optical waveguide. When the wavelength multiplexed signal can be used within the two-dimensional waveguide as described above, a plurality of routes can be formed within the common two-dimensional waveguide. In this case, if the light emitting device of a device of one pair and the light receiving device of a device of another pair are individually tunable, the devices of these pairs can be connected with wavelength changed. Furthermore, devices of two pairs can be simultaneously connected with a plurality of different wavelengths.

[0011]

Each of the plurality of devices can be configured to include each constituent provided on an electronic circuit/optical device substrate and be placed on the two-dimensional optical waveguide.

[0012]

The devices can be configured to be placed on a substrate provided on the

two-dimensional optical waveguide, such as a substrate (for example, a printed circuit board) on which electronic components are mounted. In this case, the substrate and the two-dimensional waveguide are stacked on each other (separately formed and then stacked), or the substrate and two-dimensional waveguide are layered on each other (one is layered on the other by application or the like). Arranging two transmission media close to each other as described above can more easily reduce the scale of the configuration. Moreover, an integrated medium can be used in the same manner as the substrate on which electronic devices are mounted, such as a conventional printed circuit board.

[0013]

The plurality of devices can be placed on the two-dimensional optical waveguide directly or with the electronic circuit/optical device substrate interposed therebetween.

[0014]

When the devices are provided on the two-dimensional waveguide without the substrate interposed therebetween, an electrical wire is formed on a surface of the two-dimensional optical waveguide. This configuration can eliminate the substrate for electrical wiring.

[0015]

An optical input/output terminal device having a needle-shaped end stuck in the two-dimensional optical waveguide can be used. With this configuration, light outputted from the optical device can be efficiently guided into the two-dimensional optical waveguide and the like and easily and efficiently couple the optical device and two-dimensional optical waveguide. This optical input/output terminal device is composed of an optical fiber with an end sharply machined.

[0016]

An optical input/output terminal device formed of an optical waveguide is used, and an end face of the optical waveguide may be pressed against the two-dimensional optical waveguide. An optical signal traveling in the optical waveguide and light propagating within the two-dimensional optical waveguide can be therefore coupled by scattering at a portion of the two-dimensional optical waveguide abutting on a pressure contact portion of the optical waveguide. In this case, the force of pressing the end face of the optical waveguide against the two-dimensional optical waveguide is adjusted and fixed at the state to properly set the degree of scattering at the portion of the two-dimensional optical wavelength abutting on the pressure contact portion of the optical waveguide. This can also easily and efficiently couple the optical device and the two-dimensional optical waveguide.

[0017]

A corrugated or rough surface is formed in the surface of the two-dimensional optical wavelength, and the end face of the optical input/output terminal device is brought close to or in contact with the corrugated or rough surface. The optical signal traveling in the optical input/output terminal device and light propagating within the two-dimensional optical waveguide can be therefore coupled by scattering by the corrugated or rough surface.

[0018]

Moreover, a scatterer is incorporated in the two-dimensional optical waveguide, and the end face of the optical input/output terminal device is brought close to or in contact with a portion where the scatterer is incorporated. The optical signal traveling in the optical input/output terminal device and light propagating within the two-dimensional optical waveguide can be therefore coupled to each other.

[0019]

An optical input/output terminal device composed of a prism is used, and an end face of the prism is in contact with the surface of the two-dimensional optical waveguide. A prism coupler is thus provided between the waveguide from the optical device and the two-dimensional optical waveguide, and the optical device and two-dimensional optical waveguide can be therefore easily and efficiently coupled to each other.

[0020]

An optical input/output terminal device can be formed so as to be capable of emitting light in all directions of 360 degrees within the two-dimensional optical waveguide. This example is described in the sixth embodiment. In the case of an optical fiber with an end sharpened, this end only needs to be sharpened into a cone. An optical input/output terminal device can be formed so as to be capable of receiving light propagating from any direction within the two-dimensional optical waveguide. Also in this case, in the case of an optical fiber with an end sharpened, this end only needs to be sharpened into a cone. The optical input/output terminal device configured to have the omnidirectional characteristic as described above enables one-to-n (more than 1) data communication with optical signals between the devices. Moreover, it is possible to implement a configuration in which an optical signal outputted from the device can be received by each of the other devices or to implement a configuration in which a certain device can receive an optical signal propagating from any direction.

[0021]

An optical input/output terminal device can be formed so as to emit light in a certain angular range within the two-dimensional optical waveguide. Moreover, an optical input/output terminal device can be formed so as to receive light propagating in a certain angular range within the two-dimensional optical waveguide. As an example thereof, in the case of an optical fiber with an end sharpened, an optical input/output terminal device can be composed of an optical fiber including a diagonal face formed by being obliquely cut at this end, an optical fiber with this diagonal face made concave or convex, or the like. It is therefore possible to implement a configuration in which a device transmits and receives optical signals to and from another device located in a specific direction. With the configuration in which the angle of light emitted into the two-dimensional waveguide by the optical input/output terminal device of the device is limited to a certain range and the direction of propagating light which the optical input/output terminal can receive is limited to a certain angle, pairs of the devices can use different portions in the single two-dimensional waveguide, and a plurality of independent routes can be formed in the single two-dimensional waveguide.

[0022]

The two-dimensional optical waveguide can be a configuration composed of a core sandwiched by clads.

[0023]

Furthermore, an optical waveguide method to achieve the aforementioned object is characterized in that an end of an optical input/output terminal device is brought close to, brought in contact with, or inserted into a two-dimensional optical waveguide two-dimensionally expanding and that light from an optical output section of an optical device optically coupled to the other end of the optical input/output terminal device or light to be inputted to an optical input section of the optical device is guided by the two-dimensional optical waveguide. This can provide extremely great flexibility in a placement position of the optical input/output terminal device on the two-dimensional waveguide, thus increasing the flexibility in device arrangement.

[0024]

[Embodiments of the Invention]

Hereinafter, a description is given of embodiments of the present invention with reference to the drawings.

[0025]

(First Embodiment)

FIG. 1 is a perspective view best showing a characteristic of the configuration of a first embodiment of the present invention. In the same drawing, reference numeral 1 denotes a two-dimensional optical waveguide (optical mat) (rectangular in the example shown in the drawing) expanding two-dimensionally. Reference numeral 2 denotes a substrate like a printed circuit board used to mount electronic devices and the like, and reference numerals 31 and 32 denote devices (optoelectronic devices). Furthermore, reference numerals 311 and 321 denote electrical terminals of the devices 31 and 32, respectively. The electrical terminals 311 and 321 are connected to each other through an electrical wire 4 on the substrate 2. Reference numerals 312 and 322 denote optical terminals to input light to the devices 31 and 32 and output light from the devices 31 and 32, respectively. The optical terminals 312 and 322 are stuck in the two-dimensional optical waveguide 1.

[0026]

In the case of this embodiment, the optical terminals 312 and 322, respectively, pass through substrates of the devices 31 and 32 (an electronic circuit/optical device substrate 53 show in FIG. 2) and the substrate 2 to reach the two-dimensional optical waveguide 1. The substrate 2 and the two-dimensional optical waveguide 1 are superimposed on each other so as to be in close contact with each other.

[0027]

The two-dimensional optical waveguide 1 used here has a three-layer structure as shown in FIG. 2(e). Specifically, clads 12 are formed so as to sandwich a core 11 to constitute the two-dimensional optical waveguide 1. The thickness of the core 11 is, for example, 1 mm (thickness of this level is required since the optical terminals 312 and 322 are stuck therein), and the thickness of the clads 12 is, for example, 50 μm.

[0028]

FIG. 2 shows an example of the configuration of the device 31. Herein, the device 31 is described as a transmission device. The device 31 includes an electronic circuit 50 equivalent to a conventional IC or LSI, an optical device 51 capable of emitting light (a semiconductor laser, LED, or the like), an optical terminal (optical fiber) 52 to connect the optical device 51 and the two-dimensional optical waveguide 1,

and the electronic circuit/optical device substrate 53 supporting these devices (FIGS. 2(a) and 2(b)). The optical terminal 52 is, for example, an optical fiber obliquely cut at both ends. Using the obliquely-cut face 52a, light outputted from the optical device 51 is guided into the fiber 52 and propagates in the optical fiber 52. The propagating light is reflected on a diagonal face 52b obliquely formed at the opposite end (which is stuck in the two-dimensional optical waveguide 1) of the optical fiber 52 and released into the two-dimensional optical waveguide 1 (FIG. 2(c) shows an enlarged view around the optical device 51 and optical fiber 52, and FIG. 2(d) shows a state where the optical fiber 52 penetrates through the electronic circuit/optical device substrate 53 and the substrate 2 to reach the two-dimensional optical waveguide 1). Preferably, a reflective film is provided on the diagonal face of the optical fiber in order to increase reflectivity (the same applies below).

[0029]

FIG. 3 shows an example of the configuration of the other device 32. Herein, the device 32 is described as a reception device. In the case of reception, the light in the two-dimensional optical waveguide 1 is reflected on a diagonal face 62b at the top end of an optical fiber 62, which is stuck in the two-dimensional optical waveguide 1, and propagates in the optical fiber 62. The light propagating in the optical fiber 62 reaches a diagonal face 62a at the opposite end of the optical fiber 62 and is reflected here. The light is thus irradiated onto a photodetector 61 (a photodiode or the like), which is located so as to face the opposite end face of the optical fiber, and received by the photodetector 61 to be converted into an electrical signal (FIG. 3(a) to 3(d)). The electronic circuit 60 and electronic circuit/optical device substrate 63 correspond to the electronic circuit 50 and electronic circuit/optical device substrate 53 of FIG. 2, respectively.

[0030]

Data transmission and reception by electrical signals can be performed by using the electrical wire in the same way as the conventional one. In FIG. 1, as an example, the electrical terminals 311 and 312 of the devices 31 and 32 are connected through the electrical wire 4, and data transmission and reception between the devices 31 and 32 can be performed using this wire 4.

[0031]

In addition, wires to supply power to the devices 31 and 32 and wires to electrically transmit/receive data to/from other IC and LSI, which are not shown in the drawings, are formed on the substrate 2.

[0032]

Such a configuration enables data transmission and reception between the devices to be performed using the electrical signal in addition to the optical signal. The advantage of using the optical signal is that the propagation delay time is considerably shorter than the case using the electrical signal. The arrangement of each device can be freely selected since the propagation delay time is short. Consequently, the configuration using the two-dimensional optical waveguide and optical input/output terminal device of the present invention enables this free arrangement.

[0033]

(Second Embodiment)

FIG. 4 shows a second embodiment of the present invention. The second embodiment shown in the drawing basically has a same configuration as that of the first embodiment. The different point is that both the devices 31 and 32 can transmit and receive optical signals. Each of the optical devices 31 and 32 is therefore configured so as to incorporate a light emitting device and a light receiving device, and the both devices are optically coupled to the optical input/output terminal 312 or 322.

[0034]

FIG. 5 shows the configuration of the devices 31 and 32. Reference numeral 70 denotes an electronic circuit; 72, an optical input/output terminal; 711, a light emitting device; 712, a light receiving device; 713, an optical junction device (for example, a beam splitter, a half mirror, a polarizing beam splitter, or the like); and 73, an electronic circuit/optical device substrate supporting these devices. Light outputted from the light emitting device 711 changes its optical path through the beam splitter 713 to be guided to the optical input/output terminal 72. On the other hand, in an optical signal inputted from the two-dimensional optical waveguide 1 to the optical input/output terminal 72, a component penetrating the beam splitter 713 and going straight is inputted to the light receiving device 712 and converted to an electrical signal. By the electronic circuit 70, operations of the light emitting and receiving devices 711 and 712 are controlled, and the signal processing is performed.

[0035]

Forming the apparatus in such a manner enables transmission and reception between the devices to be performed with optical signals.

[0036]

(Third Embodiment)

FIG. 6 shows a third embodiment of the present invention. In FIG. 6, three or more devices are mounted on the substrate 2. An optical signal is outputted from the first device 31 to the two-dimensional optical waveguide 1 using the optical input/output terminal 312. In the two-dimensional optical waveguide 1, light propagates and spreads (light spreads in the in-plane direction that there is no confining structure. In FIG. 6, dashed lines indicate a fun-like shape as a way how light reflected on a diagonal face of an optical fiber obliquely cut at an end is spreading). The optical signal reaches the optical input/output terminals 322 and 332 of the second and third devices 32 and 33. The second and third devices 32 and 33 can thus receive the optical signal.

[0037]

The optical input/output terminal 312 of the device 31 shown in this embodiment has a structure like a fiber obliquely cut as shown in the first embodiment. Accordingly, light spreads and propagates on one side from the optical input/output terminal 312 to form a fan-shaped spread as shown in FIG. 6. Each of the optical input/output terminals 322 and 332 on the light receiving side may be configured such that the diagonal end face of the optical fiber obliquely cut is directed to the direction from which the light comes to reflect the light and guide the light to the light receiving device of the device 32 or 33.

[0038]

(Fourth Embodiment)

FIG. 7 shows a fourth embodiment of the present invention. In FIG. 7, four

devices 31 to 34 are mounted on the substrate 2. To perform data transmission and reception between the four devices, herein, data is transmitted and received between the first and second devices 31 and 33 using an optical signal 400 with a wavelength λ1 and between the third and fourth devices 32 and 34 using an optical signal 401 with a wavelength λ2. In this example, the first and second devices 31 and 32 are connected to each other through the electrical wire 4, and data transfer therebetween is performed through an electrical signal.

[0039]

To use wavelength information in data reception and transmission as described above, wavelength selecting means is introduced into the devices. A simplest example of the wavelength selecting means is a band-pass filter. For example, when a filter composed of a dielectric multilayer film is used before the photodetector, only an optical signal with a specific wavelength can be received.

[0040]

FIG. 8 shows a configuration of an optical section inside each device. The drawing is similar to FIG. 5(b). An optical filter 820 is inserted between a light receiving device 812 and a beam splitter 813. The light receiving device 812 can therefore receive only an optical signal with a specific wavelength. Reference numeral 80 denotes an electronic circuit; 82, an optical input/output terminal; and 83, an electronic circuit/optical device substrate supporting the devices.

[0041]

In this embodiment, transmission devices of the two devices 31 and 32 output light with different wavelengths. Transmission wavelengths of the optical filters 820 within the devices 33 and 34 are set so that receiving devices of the two devices 33 and 34 can receive optical signals with different wavelengths.

[0042]

When this wavelength selecting means is a so-called tunable filter whose transmission wavelength is changed by external control (voltage control or the like), the wavelength selecting means can transmit an optical signal with an arbitrary wavelength, and the flexibility of the entire circuit is increased (for example, the combination of transmitting and receiving devices can be changed).

[0043]

Moreover, in terms of wavelength of light sources on the devices 31 and 32 side, briefly, this embodiment can be constituted by using a light source capable of emitting light with a wavelength previously determined on each device. Herein, when a so-called wavelength tunable light source capable of changing the wavelength of outputted light by external control is used as the light source, the wavelength of the optical signals used in the devices 31 and 32 can be freely selected to some extent, thus increasing the flexibility of the entire circuit. As described above, the wavelength of the light sources and the transmission wavelength of the filter of the receiving unit are made flexible. The flexibility in the circuit design can be therefore further increased compared to the case where any one thereof is made flexible.

[0044]

(Fifth Embodiment)

FIG. 9 shows a fifth embodiment of the present invention. In the drawing,

reference numeral 100 denotes an optical terminal emitting light from the device 32 to space (light may be directly outputted from the light emitting device, or light may be guided from the light emitting device by the above-described optical terminal such as the optical fiber and outputted t from the end face thereof). Reference numeral 101 denotes a light receiving device of the device 33 which receives light propagating in air (similarly, light may be directly received by the light receiving surface of the light receiving device or may be received by the end face of the above-described optical terminal such as the optical fiber and guided to be received by the light receiving device).

[0045]

In this embodiment, communication between the devices 32 and 33 adjacent to each other is performed with optical signals propagating in space, and data transmission and reception between the devices 31 and 32 comparatively distant from each other is performed with optical signals using the two-dimensional optical waveguide 1. Exchange of optical signals can be therefore performed not only within the two-dimensional optical waveguide 1 but also in space, and light within the two-dimensional optical waveguide 1 can be efficiently utilized. Herein, the reference numerals 100 and 101 are set to the transmission side and reception side, respectively, but space transmission terminals each including light emitting and receiving devices may be formed on both sides for two-way communication.

[0046]

(Sixth Embodiment)

Each of the first to fifth embodiments has the structure in which the optical input/output terminal composed of, for example, an optical fiber is stuck in the two-dimensional optical waveguide 1. In this embodiment, another configuration is shown. The configuration is shown in FIG. 10. FIG. 10 shows a portion where the two-dimensional optical waveguide 1 and the optical input/output terminal 312 are optically coupled to each other. Herein, the flat end face of the optical fiber 312 penetrates the electronic circuit/optical device substrate 53 and the substrate 2 to be pressed against the flat face of the two-dimensional optical waveguide 1. With such a configuration, light is scattered at the interface between the optical fiber 312 and the two-dimensional optical waveguide 1 and spread in all directions of 360 degrees from the point where the optical fiber 312 is in contact with the two-dimensional optical waveguide 1, thus propagating within the two-dimensional optical waveguide 1. This state is shown in FIG. 11.

[0047]

FIG. 11 shows a state where the device 31 is mounted on the substrate 2 laminated on the two-dimensional optical waveguide 1 and an optical signal is isotropically propagating in the two-dimensional optical waveguide 1. Since the optical signal propagates as shown in the drawing, if the optical input/output terminals (not shown) of other devices are placed at a same distance around the optical input/output terminal 312 of the device 31, these devices can simultaneously receive the same signal.

[0048]

In order to make optical signals incident into the two dimensional optical waveguide 1 by contact or make the optical signal within the two-dimensional optical waveguide 1 incident to the optical input/output terminal, there are a method using a

prism and the like. When the prism is attached to the top end of the optical input/output terminal, one end face of the prism only needs to be in contact with the two-dimensional optical waveguide.

[0049]

The two-dimensional optical waveguide used here does not need to have the three-layer structure shown in the first embodiment. Even when the two-dimensional optical waveguide has a structure formed of only a core (in this case, air serves as the clad layers), pressing the optical input/output terminal 312 causes light to be widely scattered within the two-dimensional optical waveguide 1 and propagate within the waveguide 1. Moreover, when the end face of the optical fiver is formed to be a diagonal face as described above and this diagonal face is pressed against the flat surface of the two-dimensional optical waveguide 1, the direction that the light propagates can be limited to an angular range, or the range of the light receiving angle can be limited.

[0050]

Moreover, when the two-dimensional optical waveguide 1 includes a scattering structure (for example, a part of the surface is made corrugated or rough, or a scatterer is inserted within the waveguide 1), the optical input/output terminal only should be located so as to be close to or in contact with the surface of the two-dimensional optical waveguide.

[0051]

(Seventh Embodiment)

FIG. 12 shows a configuration of a seventh embodiment. In this embodiment, the two-dimensional optical waveguide and substrate (the substrate 2 described above) are integrated. The wire pattern 4 is formed on the two-dimensional optical waveguide 1, and power supply or transmission/reception of electrical signals are performed through the wire pattern 4. Furthermore, optical signals can be exchanged through the two-dimensional optical waveguide 1 as a transmission path using the optical input/output terminals 312 and 322 provided for the respective devices 31 and 32. With such a configuration, the number of components can be reduced compared to the two layer structure of the substrate and two-dimensional optical waveguide shown in the first to sixth embodiments. In the example shown in FIG. 12, the configuration of this embodiment is applied to the configuration of the first embodiment but can be similarly applied to the configurations of the second to sixth embodiments.

[0052]

[Effect of the Invention]

As described above, using the two-dimensional optical waveguide and the device corresponding thereto can provide greater flexibility in device arrangement than before, thus constituting a high-performance optical or optoelectronic circuit.

[Brief Description of the Drawing]

[FIG. 1] FIG. 1 is a perspective view showing a configuration of a first embodiment of the present invention.

[FIG. 2] FIG. 2 includes views explaining a configuration of a light emitting device shown in FIG. 1 at various angles.

[FIG. 3] FIG. 3 includes views explaining a configuration of a light receiving device shown in FIG. 1 at various angles.

[FIG. 4] FIG. 4 is a perspective view showing a configuration of a second embodiment of the present invention.
[FIG. 5] FIG. 5 includes views explaining a configuration of a part around an optical device as an device of the second embodiment.
[FIG. 6] FIG. 5 is a perspective view showing a configuration of a third embodiment of the present invention.
[FIG. 7] FIG. 6 is a perspective view showing a configuration of a fourth embodiment of the present invention.
[FIG. 8] FIG. 8 is a perspective view explaining a configuration of a part around an optical device of an device of the fourth embodiment.
[FIG. 9] FIG. 9 is a perspective view showing a configuration of a fifth embodiment of the present invention.
[FIG. 10] FIG. 10 is a cross-sectional view explaining an optical connection between an optical input output terminal and a two-dimensional optical waveguide of a sixth embodiment of the present invention.
[FIG. 11] FIG. 11 is a perspective view showing a way how light spreads in the configuration of FIG. 10.
[FIG. 12] FIG. 12 is a perspective view showing a configuration of a seventh embodiment of the present invention.
[FIG. 13] FIG. 13 is a view explaining a conventional art.
[Explanation of Reference Numerals]
1: TWO-DIMENSIONAL OPTICAL WAVEGUIDE (OPTICAL MAT)
2: DEVICE SUBSTRATE
4: ELECTRICAL WIRE (WIRE PATTERN)
11: CORE OF TWO-DIMENSIONAL OPTICAL WAVEGUIDE
12: CLAD OF TWO-DIMENSIONAL OPTICAL WAVEGUIDE
31-34: DEVICE
50, 60, 70, 80: ELECTRONIC CIRCUIT (IC, LSI)
51, 61: OPTICAL DEVICE
52, 62, 72, 82: OPTICAL FIBER (OPTICAL TERMINAL)
52A, 52B, 62A, 62B: DIAGONAL FACE OF OPTICAL TERMINAL
53, 63, 73, 83: ELECTRONIC/OPTICAL DEVICE SUBSTRATE
100, 101: SPACE TRANSMISSION TERMINAL
311, 321, 331: ELECTRICAL TERMINAL
312, 322, 332, 342: OPTICAL INPUT/OUTPUT TERMINAL
400, 401: OPTICAL SIGNAL
711, 811: LIGHT EMITTING DEVICE
712, 812: LIGHT RECEIVING DEVICE
713, 813: BEAM SPLITTER
820: OPTICAL FILTER

FIG. 1
32: DEVICE
322: OPTICAL TERMINAL
312: OPTICAL TERMINAL
31: DEVICE
311: ELECTRICAL TERMINAL
2: SUBSTRATE
1: OPTICAL WAVEGUIDE (OPTICAL MAT)
4: ELECTRICAL WIRE
321: ELECTRICAL TERMINAL

FIG. 2
(a) TOP VIEW
50: ELECTRONIC CIRCUIT
51: OPTICAL DEVICE
52: OPTICAL FIBER
53: ELECTRONIC CIRCUIT/OPTICAL DEVICE SUBSTRATE

(b) SIDE VIEW

(c) CONFIGURATION AROUND OPTICAL TERMINAL
51: OPTICAL DEVICE

(d) CROSS-SECTIONAL VIEW OF (c)
LIGHT
2: SUBSTRATE
1: TWO-DIMENSIONAL OPTICAL WAVEGUIDE (OPTICAL MAT)
LIGHT (TRAVEL TO NEAR SIDE)

(e) CONFIGURATION OF OPTICAL MAT
12: CLAD
11: CORE
12: CLAD

FIG. 3
(a) TOP VIEW
60: ELECTRONIC CIRCUIT
61: OPTICAL DEVICE
62: OPTICAL FIBER
63: ELECTRONIC CIRCUIT/OPTICAL TERMINAL SUBSTRATE

(b) SIDE VIEW

(c) CONFIGURATION AROUND OPTICAL TERMINAL
61: OPTICAL DEVICE

(d) CROSS-SECTIONAL VIEW OF (c)
LIGHT
2: SUBSTRATE
1: TWO-DIMENSIONAL OPTICAL WAVEGUIDE (OPTICAL MAT)
LIGHT (TRAVEL FROM NEAR SIDE)

FIG. 4
312: OPTICAL TERMINAL
31: DEVICE
311: ELECTRICAL TERMINAL
2: SUBSTRATE
1: OPTICAL WAVEGUIDE (OPTICAL MAT)
4: ELECTRICAL WIRE

FIG. 5
(a) TOP VIEW
712: LIGHT RECEIVING DEVICE
711: LIGHT EMITTING DEVICE
(b) 713: BEAM SPLITTER

FIG. 6
1: OPTICAL WAVEGUIDE (OPTICAL MAT)
2: SUBSTRATE
31: DEVICE
311: ELECTRICAL TERMINAL
4: ELECTRICAL WIRE
312: OPTICAL TERMINAL
OPTICAL SIGNAL

FIG. 7
312: OPTICAL TERMINAL
31: DEVICE
311: ELECTRICAL TERMINAL
401: OPTICAL SIGNAL
2: SUBSTRATE
1: OPTICAL WAVEGUIDE (OPTICAL MAT)
400: OPTICAL SIGNAL
4: ELECTRICAL WIRE

FIG. 8
820: OPTICAL FILTER

FIG. 9
312: OPTICAL TEMRINAL

31: DEVICE
311: ELECTRICAL TERMINAL
2: SUBSTRATE
1: OPTICAL WAVEGUIDE (OPTICAL MAT)
4: ELECTRICAL WIRE
100: SPACE TRANSMISSION TERMINAL

FIG. 10
312: OPTICAL INPUT/OUTPUT TERMINAL
1: TWO-DIMENSIONAL OPTICAL WAVEGUIDE

FIG. 11
31: DEVICE

FIG. 12
OPTICAL SIGNAL
312: OPTICAL TERMINAL
31: DEVICE
311: ELECTRICAL TERMINAL
1: OPTICAL WAVEGUIDE (OPTICAL MAT)
4: ELECTRICAL WIRE

FIG. 13
811: OUTPUT LENS
805: OPTICAL BEAM
810: REFLECTIVE LAYER
809: SECOND TRANSPARNT LAYER
808: FIRST TRANSPARENT LAYER
807: OPTICAL WAVEGUIDE PLATE
812: INPUT LENS
802: LIGHT EMITTING CHIP
803: LIGHT RECEIVING CHIP
801: SIGNAL PROCESSING SUBSTRATE
804: LIGHT EMITTING DEVICE
805: LIGHT RECEIVING DEVICE

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F Term (Reference) 2H037 BA01 BA11 BA21 CA07 CA10
CA32 DA03
2H047 KA02 KB09 MA03 MA05 MA07
TA47

FIG. 1

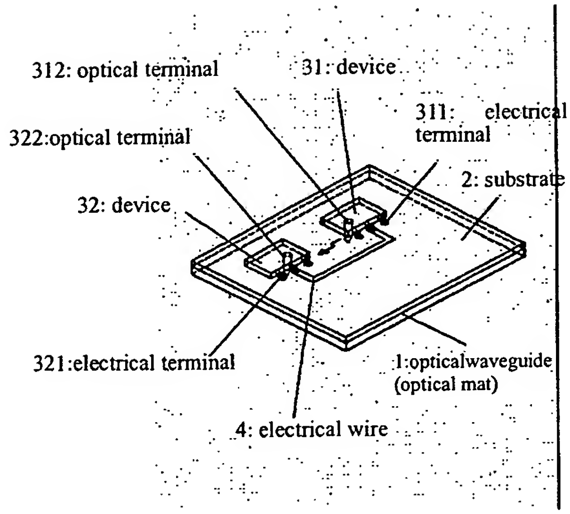


FIG. 2

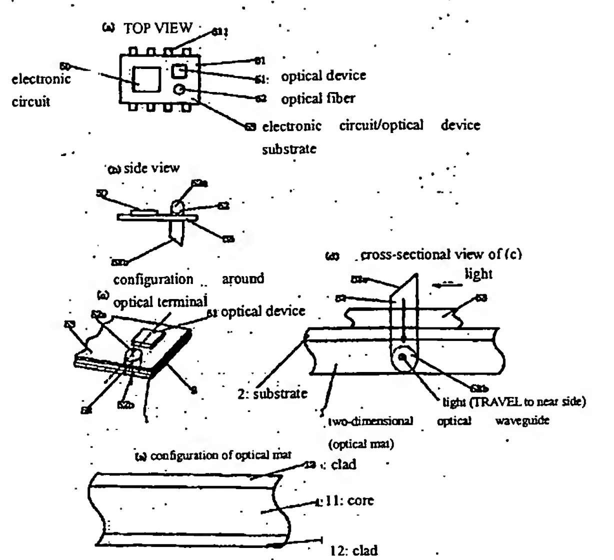


FIG. 3

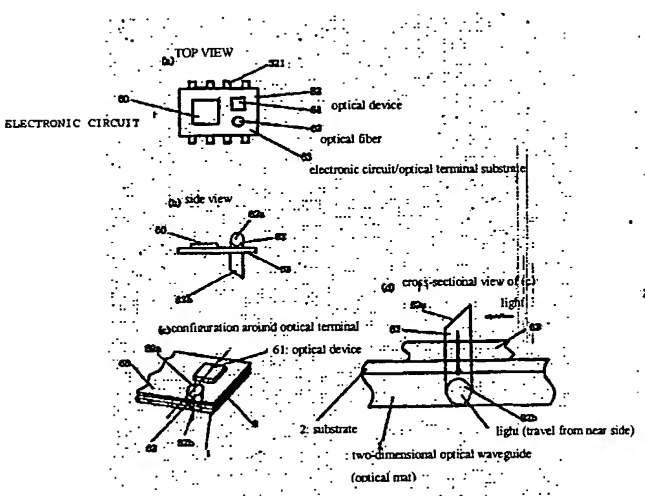


FIG. 4

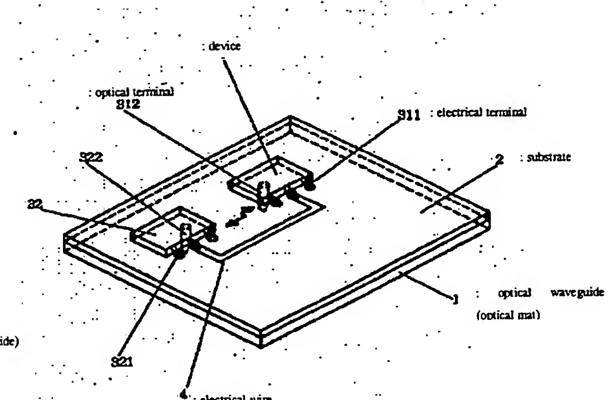


FIG. 5

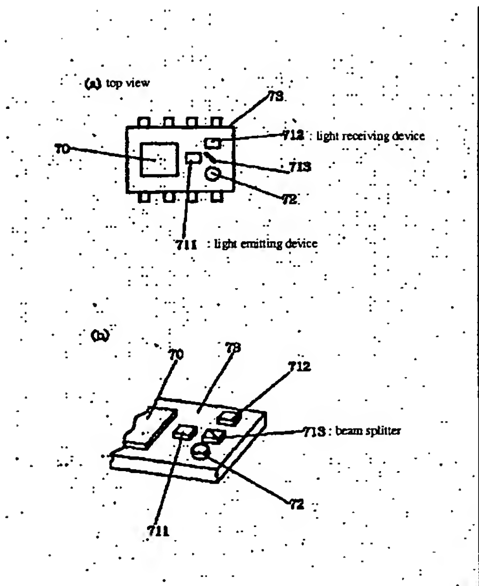


FIG. 6

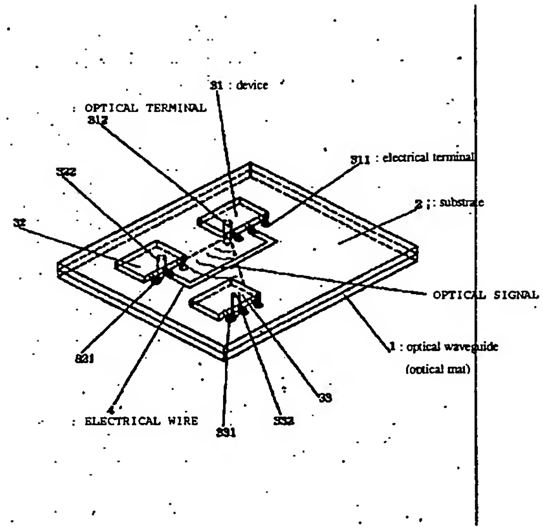


FIG. 7

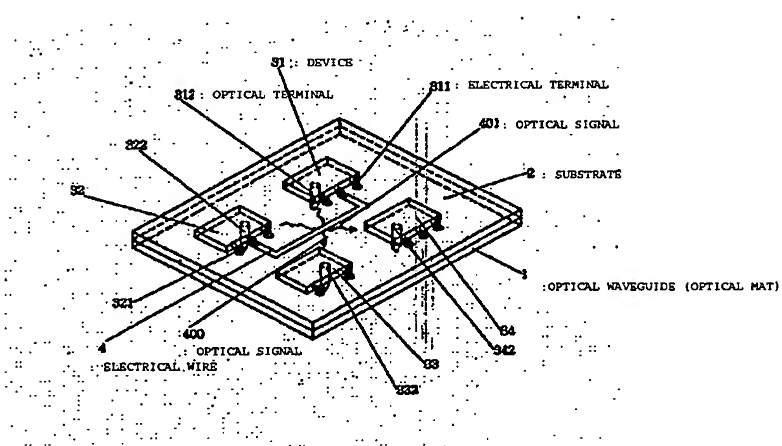


FIG. 8

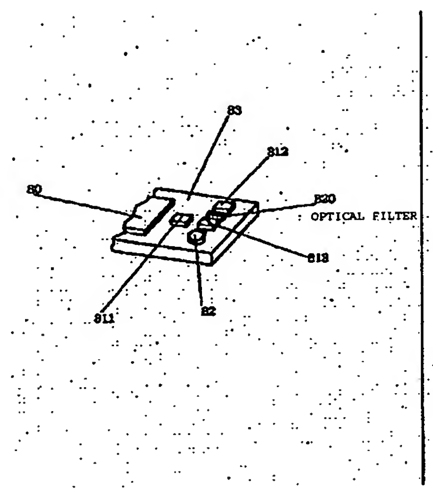


FIG. 10

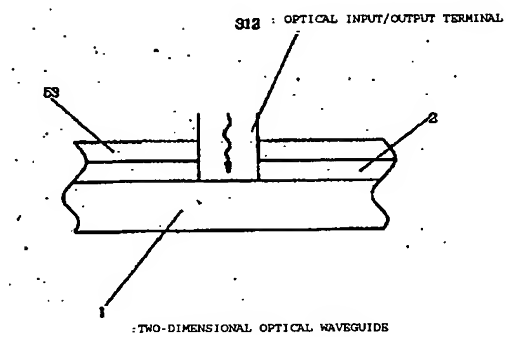


FIG. 9

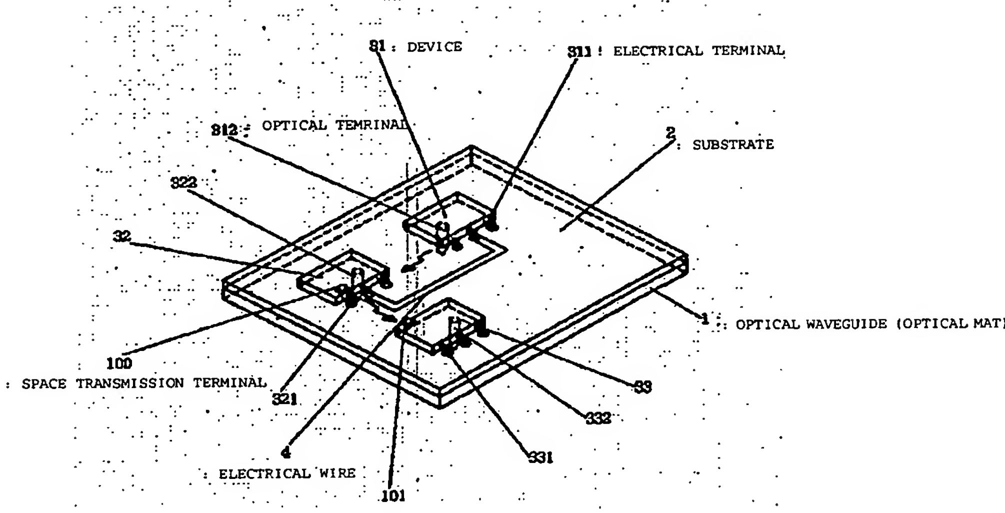


FIG. 11

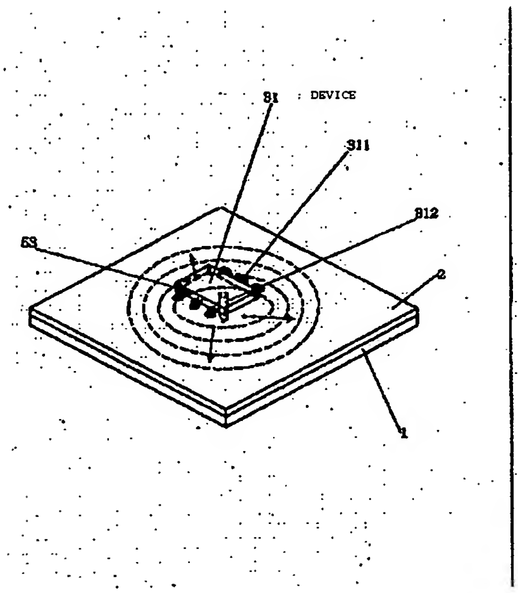

81 : DEVICE
311
312
63
2
1

FIG. 12

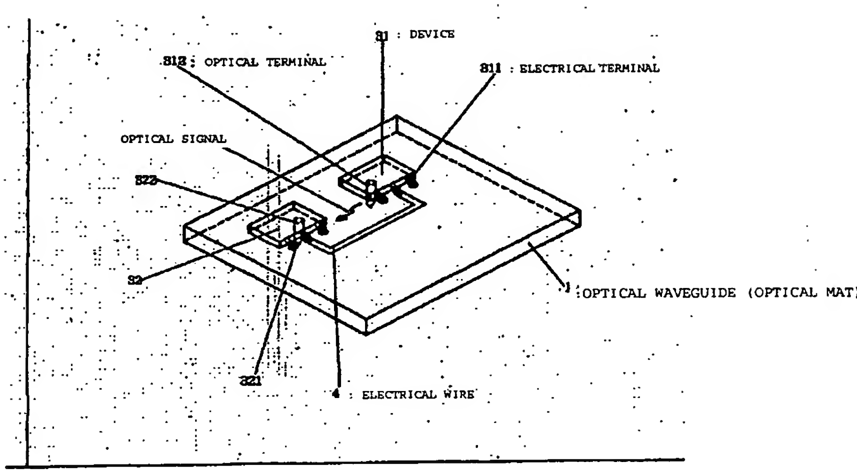
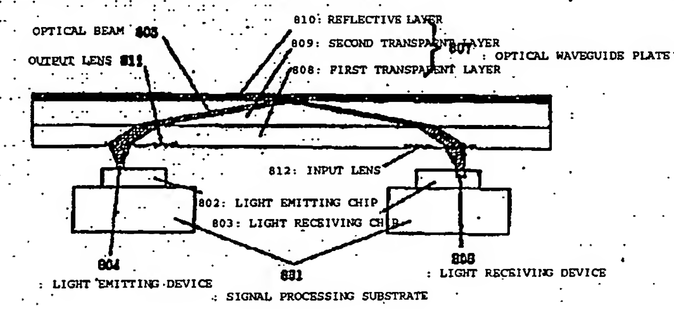

81 : DEVICE
812 : OPTICAL TERMINAL
811 : ELECTRICAL TERMINAL
OPTICAL SIGNAL
822
82
1 :OPTICAL WAVEGUIDE (OPTICAL MAT)
821
4 : ELECTRICAL WIRE

FIG. 13



810: REFLECTIVE LAYER
OPTICAL BEAM 805
809: SECOND TRANSPARENT LAYER
807 : OPTICAL WAVEGUIDE PLATE
OUTPUT LENS 811
808: FIRST TRANSPARENT LAYER
812: INPUT LENS
802: LIGHT EMITTING CHIP
803: LIGHT RECEIVING CHIP
804
: LIGHT EMITTING DEVICE
801
: SIGNAL PROCESSING SUBSTRATE
806
: LIGHT RECEIVING DEVICE